THE NEEDS OF HYBRID SYSTEMS CONFIGURATION FOR REAL – TIME DECISION – MAKING PROCESS IN SURGERY

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Abstract-**Hybrid systems and techniques, combining data-driven learning techniques (such as neural networks) with knowledge-driven techniques (such as fuzzy rules) begin to be extensively applied in the biomedical field, especially for signal analysis and interpretation and for computer-controlled systems. A real need for design and configuration of dedicated hybrid systems in modern surgery is raising: sensors, actuators, mechatronic systems and tools in Minimally Invasive Surgery (MIS) and Microsurgery require non-linear interpretation and control systems to interface with the computer-assisted decision-making process of the surgeon at work. The design and the configuration techniques for real-time hybrid systems must fit the new technological advances in terms of specific (micro) sensors and multi-sensors and in terms of feed-back tool action-tissue reaction response and measurements.**

BACKGROUND

THE REAL-TIME DECISION-MAKING PROCESS IN SURGERY

The real-time decision-making process in surgery was linked to the clinical evaluation and expertise of the surgeon and based on the classical doctor-patient relationship. The introduction of medical imaging technologies permitted to establish general guidelines for diagnosis and staging to select a range of techniques or surgical strategies that could fit the spectrum of pathological possibilities. Dynamic medical imaging technologies in pre-operative staging permit to quantify and to qualify the pathologies, their degree and the functional impairment of specific organs; measuring technologies permit to check some parameters useful to validate or to modify the surgical steps during the whole procedures.The clinical importance of this new stage in the decision-making process of the surgeon in the operating theatre is evident, considering the parameters of sensitivity and specificity of the diagnostic tools in the pre-operative stage, the use of these informations for surgical planning and performance (use or not-use, abuse, misuse, redundancy), the validation of sensor informations and interpretation in the operating theatre and the implementation on the surgical steps in real-time.

THE FUTURE

THE REAL-TIME DECISION-MAKING PROCESS IN SURGERY, SUPPORTED BY BIOENGINEERING AND INFORMATION TECHNOLOGIES

Future perspectives:The five levels of intervention of hybrid systems
On a pratical point of view for clinical application, **real-time hybrid systems** must be distinguished by **structural hybrid systems**: their roles are different in relations to the tools and to the type of measurements or actions that must be controlled and to the complexity of integration that must be handled. The levels of interventions of real-time and structural hybrid systems can be independent or can be shared in controlled tasks in order to accomplish a complex strategy.
Sensors: Sensors in surgery permit the real-time analysis of the biomedical signal. The variability and the fluctuation of biomedical signals in the special conditions of anesthesia and surgical room environment suggest the need to use real-time hybrid system dedicated to.(**The first level of intervention of real-time hybrid systems**).
The needs to obtain many informations (many signals) support the justification to have many sensors. The concept of a **multi-sensor** can be applied to collect many informations with one small probe;(1) but a multi-sensor, even if collects multiple signals, sustains the need of integration for interpretation: naturally this step cannot be conducted in the operating theatre, because this is a wasting time procedure, and it necessitates of a pre-modelling and simulation process of the physio-pathological compartments involved in the surgical steps in order to respect the allocated time for surgery**. This is the second level of intervention in real-time hybrid systems**, sharing with the process of integration in modelling and simulation dedicated to real-time hybrid systems: **The third level of structural hybrid systems**)
Actuators: The characteristics of the decision-making process in the surgical theatre are very specific : the decision process is not intellectual, it must be transferred in action with actuators. Control of actuators is linked to the degree of

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freedom and to the particular motion specifically engaged on the target**. (The second level of intervention of real-time hybrid systems)**
The decision making process with mechatronic tools: (2) **The third level of intervention**: integration from target information – modelling and simulation - calibrated mechatronic tool action for real-time hybrid systems.(3)

The hidden levels of intervention of structural hybrid systems: The fourth and fifth levels
Both levels are strictly linked to the chaos theory application to the multidimensional clinical and surgical platforms (4) and attempt to optimize the connectivity among medical neural networks (object -oriented) and clinical neural networks (user -oriented).(5)

BEHIND THE DEDICATED TECHNOLOGY FOR OPERATIVE SURGERY
The decision-making process of the surgeon is a complex task in which synergistic combination of many techniques must result in more strengths and less weaknesses than either technique alone. The selection and the configuration pattern of hybrid systems working with different time-scale domains and embedded in specific time-space dimensions have great potential for solving difficult tasks, but are very critical if used inappropriately. In clinical current practice the performance of the model is the single most important criterion for success. In a target-oriented multi-task system as in a surgical procedure a supervised strategy to create the appropriate configuration to combine different techniques to form hybrids must be considered, specifying the primary goals of the procedures and the levels of performances required in the surgical task.
The needs of hybrid systems configuration for real-time decision-making process in surgery are based on the fact that analytical methods do not exist for verification of hybrid control system;but a simulation tool can be useful to (in)validate that the hybrid system operates properly. On the other side real-time hybrid systems must have properties of time-space scaling and virtual geodetic representation.

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